

REMARKS/ARGUMENTS

Claims 1, 2, 6, 8, 10, 11, 19 and 20 are amended. Claims 7, 9 and 12-18 are canceled.

Reconsideration of the application is respectfully requested for the following reasons:

1. Rejection of Claims 1-8 and 10-20 Under 35 U.S.C. §112

Claims 1-8 and 10-20 are rejected under 35 U.S.C. §112, first paragraph, as failing to comply with the enablement requirement.

In general, "burn-in testing", or component testing where infant mortality failures are screened out by testing at elevated voltages and temperatures for a specified length of time, serving as an accelerated environment testing, is performed to plot in a short test period the failure rate versus age curves as shown in FIG. 1 of the present application.

The acceleration factor or coefficient of a failure rate of a bathtub curve is well-known. In Yoshida (U.S. 6,215,324), acceleration coefficient B of a failure rate is generally given by:

$$B = \exp\{-\frac{E}{k}(1/T_{jH} - 1/T_{jF})\} \quad (1)$$

where E: activation energy of a failure [eV], k: Boltzmann's constant=8.617.times.10⁻⁵ [eV/K], T_{jH} : p-n junction temperature [K] of an LSI chip at the elevated temperature in the accelerated environment testing, and T_{jF} : p-n junction temperature [K] of the LSI chip under normal and actual usage conditions.

However, the acceleration factor or coefficient of failure rate taught by Yoshida is just an example, not a limitation of the claimed invention. The bathtub experiment is also a well-known failure test for integrated circuit chips which uses elevated voltages and temperatures for a specified length of time and serves as an accelerated environment testing although different bathtub experiments may use different parameters such as voltage, time or temperature. Nevertheless, all the resulting bathtub curves should comprise an infant mortality period, a normal life period and a wear out period. The infant mortality period usually corresponds to failure induced by defects of fabrication, and usually lasts about several weeks; the normal life period usually corresponds to some random failures, and usually lasts about twenty years, thirty years or more; the wear out period usually corresponds to failure induced by long-time waste, and is continuously increased while time goes by.

An acceleration factor or coefficient of failure rate is a mathematical description of the test parameters in a bathtub experiment used to simulate the actual environment and operation conditions of a device for a limited testing time. What the "test time function" and "real time function" represent is described and explained in the amended specification. The "test time function" and "real time function" have been replaced with alternative terms. The specification and drawing are amended in nature and supported by the specification as originally filed. It is respectfully submitted that the changes do not involve new matter and therefore entry of the amendments in accordance with prescribed procedures is respectfully requested.

2. Rejection of Claims 1-20 Under 35 U.S.C. §103(a)

Claims 1-8, 11-15, and 18 are rejected under 35 U.S.C. §103(a), as being unpatentable over Boyington et al. (hereinafter Boyington) (U.S. 6,377,897), and Chien et al. (hereinafter Chien).

Applicant respectfully traverses this rejection.

Particularly, Boyington never discloses a transforming process using the acceleration factor function to transform the testing failure versus testing time function into a real failure rate versus operation time function. Boyington only uses the variation of the instantaneous rate of failure (slope) and compares the instantaneous rate of failure with specific infant mortalities identified by a computer to determine a best burn-in time. The failure rate calculation 250 of Boyington can also consider statistical analysis of past performance data, extracted from the performance database. Such analysis of the database enables the burn-in testing to be dynamically fine-tuned as the database grows. This process would allow the burn-in cycle to become more reliable through time. The failure rate calculation 250 of Boyington only enables the burn-in testing to be dynamically fine-tuned as the database grows so that Boyington never discloses a transforming process using the acceleration factor function to transform the testing failure rate versus testing time function into a real failure rate versus operation time function.

Obviously, because the claimed invention is a numerical approach method, it is reasonable that the claimed invention can decide the error range by "trial and error" and also can decide the precision of the real failure rate versus operation time function.

The essential scope of the claims is as follows (herein, only claims 1 and 19 are independent claims):

- (a) Perform a life-time testing process to acquire the life distribution of the tested samples.
- (b) Perform the "trial and approach" procedure (or called trial and error) to acquire a simulated curve, such as the test time function, where the difference between the simulated curve

and the life distributed is minimized. Herein, it is well known that the “trial and approach” procedure is used to minimize the difference between the data and the simultaneous results.

- (c) Transforms the results acquired under a testing environment into a real time life distribution by using the acceleration factor function acquired from the life-time testing process.
- (d) Determine a best burn-in time by using the real time life distribution, and further calculates some information such as the reliability of the test samples.
- (e) No formula or predetermined database is used to acquire the failure rate and the best burn-in time. At most, the stored experimental data are used to determine the period of the stress test.

Please note that no formula and no predetermined database is cited or otherwise inherent in all pending claims. Herein, how to determine the period of the life-time testing process is not limited. However, the claims of Boyington also do not limit the details. Therefore, it is reasonable to consider the determination of the period as being trivial for one of ordinary skill.

- (f) Only perform the life-time testing process during a specific period, which means the life-time testing process is only performed once in the invention. After the life-time testing process is performed, the simulated curve is acquired by the measured results of the life-time testing process.

Please note that no claim discloses the step of repeatedly performing the life-time testing process more than once. In fact, no claim discloses a standard for determining whether to repeatedly perform the life-time testing process. To explain the pending claims, it is significant that lines 13-19 of page 11 and lines 20-23 of page 12 of the specification

disclose how to improve the results but nothing is related to perform the life-time testing process more than once.

- (g) The calculation of the real failure rate versus time function (a result acquired from the simulated curve and the acceleration factor function) at least is calculated for both the infant mortality period and the normal life period. Hence, the best burn-in time could be acquired, and some information, such as the reliability of the sold products and the average lifetime of the sold product, could also be acquired.

It is respectfully contended that the pending claims have the previous limitations, such as performing the life-time testing process only once, calculating results such as reliability, applying the acceleration factor function to translate between the simulated failure rate versus testing time function and the real failure rate versus operation time function, applying the "trial and approach" procedure (between different time scales) and transforming by using the acceleration factor function. Besides, while the results during both infant mortality period and normal life period are acquired by the invention, it is implied that the pending claims relate to cost and mean residual life because the quality of products during the normal life period is important for the contemporary industry.

Furthermore, by carefully analyzing Boyington, applicant essentially summarizes the teaching of Boyington as follows:

- (a) Acquire the core time by the historical data. (the historical data could be acquired by performing experiments).
- (b) Perform the stress test (corresponding to the life-time testing process of the claimed invention) during a period which is equal to the core time, which means performing the stress test from "time = 0" to "time = core time".
- (c) Analysis of the measured data acquired by the stress test.

(d) Decide whether the slope of the function of both failure rate and time is smaller than a predetermined value during the period of the stress test.

(e) If the answer to (d) is negative, perform (a)-(c) again, which means performing the stress test from "time = core time" to "time = 2 times core time"; and

If the answer to (d) is positive, use the specific time, where the slope is just smaller than the predetermined value, to be the best burn-in time.

Herein, please at least refer to the following parts of Boyington: FIG. 2, col. 3 lines 16-54, and col. 3 lines 61 to col. 4 line 29.

Moreover, col. 3 lines 19-22 of Boyington clearly express that "In general, the method starts with determining a core time. From historical data of similar ICs, a core time is calculated, which is the time of stress that is to be applied to all ICs in the batch." Indisputably, Boyington considers his "core time" as the period that ICs are tested in the batch. Hence, Boyington's "core time" corresponds to the testing time of the testing environment. Besides, col. 3 lines 43-44 of Boyington further express "the core period (i.e. the minimum burn-in time)", and then the core period (or core time) directly corresponds to the burn-in time again. Further, FIG. 2 of Boyington shows that the core is acquired in the "DETERMINE CORE AND INITIA READ POINTS, 215" only after "ICS INSERTED INTO BURN-IN BOARDS, 205" and "BOARDS IN OVENS, 210". Clearly the core time is acquired directly from burn-in (the testing environment) and is independent of the normal operating environment.

Further, regarding Chien, applicant agrees that Chien really presents a simulation method that eliminates the burn-in time without the usage of parameter(s). However, applicant also finds that Chien has the following characteristics:

(a) Chien only considers how to perform the simulation by using the time-dependent data. In fact, Chien never considers the transformation between the testing time and the real time.

(b) Chien never uses the acceleration factor function.

Herein, please at least refer to the following parts of Chien: FIG. 1, page 462 (A. U-shape Failure Rate Function), page 466 (V. Examples), and partial pages 463-466 (B. Simulation and D Optimal Burn-In time).

Regarding Matsuoka, applicant does not argue with the Examiner's viewpoint about Matsuoka. In other words, applicant says nothing about what Matsuoka is.

Accordingly, by carefully comparing the invention with Boyington, applicant reasonably finds the following important differences:

(a) The invention only performs the stress test (the life-time testing process) once during a specific period. In fact, even if the measured data are insufficient, the invention still solves the problem by other methods. Please refer to page 11 lines 13-19 and page 12 lines 20-23. In contrast, Boyington may perform the stress test several times until the specific time that the slope is smaller than a predetermined value. Clearly, the times that the stress test is performed is a strong difference. Moreover, the total periods that the stress test is performed by Boyington must not be smaller than the best burn-in time. In contrast, the invention allows that the period of the performed stress test is smaller than the best burn-in time. Herein, the difference could be easily found from the pending claims.

(b) The invention calculates the best burn-in time and further calculates the results, such as reliability, in both the infant mortality period and the normal life period. In contrast, Boyington only calculates the best burn-in time and does nothing about the results in the normal life period. Thus, by referring to Boyington, there is no motivation to

study the results in the normal period. Clearly, Boyington only relates to part of the invention.

(c) The invention uses the acceleration factor function to transform between the testing time and the real time. Boyington only uses one time scale (the testing time) and never discloses anything about the transformation between difference time scales. Clearly, Boyington discloses nothing about this part of the invention. Herein, the difference could be easily found from the pending claims for the acceleration factor function being clearly described.

(d) The invention is related to both "cost" and "mean residual life". Boyington never discloses anything about these subjects. Clearly, Boyington is only related to part of the invention.

(e) The invention uses a simulated curve to fit the measured data of the performed stress test, and limits the differences between the simulated curve and the measured data is minimized. Boyington directly uses the measured data to find the slopes without any simulation, and no minimizing difference process is performed. Clearly, Boyington is only related to part of the invention.

According to the previous paragraphs (a)-(e), applicant emphasizes that the differences between the pending claims and Boyington are more than what the Examiner considered.

Furthermore, applicant emphasizes that the Examiner's viewpoint about Chien is incorrect. For example, Chien never discloses the item "acceleration factor function" (the term is not found in Chien). Hence, because the Examiner only uses Matsuoka to reject claims 19-20, the differences between claims 1-6, 8, 10 and 11 and Boyington are more than what Chien discloses.

Besides, applicant emphasizes that the scope of claims 19-20 is the combination of optimizing process and the scope of claims 1-6, 8, 10 and

11, which could be easily found by comparing claims 19-20 with claims 1-6, 8, 10 and 11. Hence, while Matsuoka is related to a monitored burn-in system and says nothing about the details of the optimizing process, claims 19-20 are strongly different from the combination of Boyington, Chien and Matsuoka.

Conclusion

In light of the above remarks to the claims, Applicant contends that the claimed invention is patentable thereover. The claims are in condition for favorable consideration and allowance of all the claims are most respectfully requested.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 07-1337 and please credit any excess fees to such deposit account.

Respectfully submitted,

LOWE HAUPTMAN GILMAN & BERNER, LLP

Benjamin J. Hauptman
Registration No. 29,310

1700 Diagonal Road, Suite 810
Alexandria, Virginia 22314
Telephone: (703) 684-1111
Facsimile: (703) 518-5499
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M thod For D t rmining Failur Rate And Selecting Best Burn-In time

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BACKGROUND OF THE INVENTION

1. Field of the Invention

10 The invention pertains to methods for determining failure rate and selecting best burn-in time, and can have particular application to provide both error range and risk estimation by numerical approach.

15 **2. Description of the Prior Art**

Accompany with increasing complexity of integrated circuits and increasing difficulties of market contest, quality and reliability of produced integrated circuits is more important than ever. Therefore, 20 how to control qualities of produced integrated circuits, how to estimate failing risk of integrated circuits while they are used by end-users, and how to balance production cost and quality promise are some important challenge of quality department of integrated circuits manufacturers.

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In general, the relation between failure rate of integrated circuits and time, both for testing and for application of end-users, usually is a bathtub curve. As shown in FIG. 1, accompanying with the

increase of time (period), the bathtub curve can be divided into infant mortality period, normal life period and wear out period. Whereby, infant mortality period usually corresponds to failure induced by defects of fabrication, and usually lasts about several weeks; normal life period usually corresponds to some random failures, and usually lasts about twenty years, thirty years or more; wear out period usually corresponds to failure induced by long-time waste, and is continuously increased while time goes by.

Because most of integrated circuits will have been replaced with new designs and new technologies before the wear out period is reached, manufactories usually only need to test all produced integrated circuits through the infant mortality period to select all failing integrated circuits that induced by imperfect fabrication. Thus, all tested integrated circuits are suitable for selling, and the only risk is some random failures. Moreover, elimination of these random failures and prolongation of normal life-time only can be achieved by improvements of fabrication of integrated circuits, but can not be achieved only by operation of quality department.

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However, owing to limitation of time, it is impossible for the quality department to test all produced integrated circuits through both the infant mortality period and the normal life period, even only through the infant mortality period. As usual, the quality department only perform a stress test, or called as accelerated test, to test produced integrated circuits through a specific period under a testing environment in which is more harmful and danger for tested integrated circuits, and then the relation between the failure rate and testing time

is measured. Then, in accordance with the difference between the difference between the testing environment and a normal operating environment to estimate the relation between failure rate and real time, in which is the experienced time under the normal environment.

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Indisputably, how to properly and correctly transform the failure rate testing time relation into the failure rate real time relation, is the key about whether failure rate time relation can be properly consulted by the stress test.

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Moreover, almost all well-known arts use mathematical formula to estimate the failure rate relation by some tested datas. For example, the popular mathematical formula is the chi square distribution $\lambda = \chi^2(2(r+1)B)/2t$. Herein, λ is the failure rate χ is the chi square function r is failing number B is confidence and t is time and value of χ is consulted from a pre-established table.

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Significantly, because the failure rate time relation is consulted by formula in accordance with testing records, well-known arts can not avoid following disadvantages: (1) the difference between the experimental value and the theoretical value can not be found by the used formula; (2) the best burn-in time only can be consulted by experience or formula, it can not be consulted by the relation between the best burn-in time and the corresponding risk; (3) the reliability of produced integrated circuits can not be promised by ensuring the estimated value is almost the best value in accordance with the comparison between the experimental value and the theoretical value.

As a short summary, it is obviously that conventional arts can not efficiently determine the failure rate time relation and select the best burn-in time. Thus, it is necessary to develop a new method to analysis the testing records of the stress test and to effectively improve 5 efficiency of quality department.

SUMMARY OF THE INVENTION

10 Objects of the present invention at least include providing a numerical method for providing both error range and risk estimation.

15 Objects of the present invention further comprise providing method for controlling qualities of produced integrated circuits, estimating failing risk of users of produced integrated circuits, and balancing requirements of both production cost and quality promise.

20 On the whole, one method present by the invention at least includes following basic steps: Method for determining failure rate and selecting a best burn-in time, comprising: provide numerous integrate 25 circuits; performs a life-time testing process, wherein a failure rate testing time relation is established by measuring the life-time of each integrated circuit under a testing environment, wherein an acceleration factor function also is established under the testing environment, the acceleration factor function is related to the relationship between a testing time of the testing environment and a real time of a normal operating environment; performs a simulating process that a testing time function is used to simulate the failure rate testing time relation;

performs a transforming process by using the acceleration factor function to transform the testing time function into a real time function, wherein a knee point of the real time function corresponds to an operation time which is the best burn-in time; and performs an 5 integrating process to integrate the real time function through a calculating region to consult an accumulated failure rate real time function, wherein the calculating region is a region in which the real time is larger than the best burn-in time.

10 Besides, the invention further comprises that while more than one integrated circuits are failed before the knee point, the method further comprising deleting part of testing records and re-calculating the best burn-in time until only one integrated circuit is fail before the knee point.

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BRIEF DESCRIPTION OF THE DRAWINGS

20 Preferred embodiments of the invention are described below with reference to the following accompanying drawings.

FIG. 1 is a brief illustration of the well-known relationship between failure rate and time for integrated circuits;

25 FIG. 2 is a brief flow chart of one preferred embodiment of this invention;

FIG. 3 is a brief flow chart of another preferred

embodiments of this invention; and

FIG. 4A through FIG. 4C are some referring figures for showing how to decide and find required knee point.

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DESCRIPTION OF THE PREFERRED EMBODIMENT

This disclosure of the invention is submitted in furtherance of
10 the constitutional purpose of the U.S. Patent Laws "to promote the
progress of science and useful arts" (Article 1, Section 8).

One major disadvantage of conventional arts that values of
15 part used parameters and values of part used functions, such as chi
square function, are consulted from some pre-established tables,
especially same pre-determined tables are used to analysis different
testing records of different samples. It is indisputable that some
20 external variables, which are not consulted from testing records, are
used to calculate the failure rate time relation, and then the failure
rate time relation can not be obtained only by testing records. Aims on
previous discussion, the claimed invention presents a way to estimate
the failure rate time relation only in accordance with testing records,
25 and then only errors induced by estimating process will be an issue
but errors induced by external variables will not be an issue.

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One preferred embodiment is a method for determining failure
rate and selecting a best burn-in time. As FIG. 2 shows, the
embodiment comprises following essential steps:

As preparing block 21 shows, provides numerous integrate circuits. Whereby, each integrated circuit is similar to other integrated circuits except unavoidable tolerance of fabricating process.

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As life-time testing block 22 shows, performs a life-time testing process to establish a experimental failure rate versus testing time relation by measuring the life-time or failure rate of each said integrated circuit under a testing environment which is well-known as 10 a bathtub experiment having a curve of experiment data with the shape similar to FIG. 1. The bathtub curve can be divided into infant mortality period, normal life period and wear out period. Moreover, an acceleration factor function or an acceleration coefficient function of the bathtub experiment also is established under the testing 15 environment. Herein, the acceleration factor function is related to the relationship between a testing time of the testing environment and a real time of the normal operating environment. Moreover, the testing environment is adjusted to let (failure rate)/(unit time) in the testing environment is larger than the (failure rate)/(unit time) in a normal 20 operating environment, and in general it is achieved by increasing working voltage of integrated circuits, increasing temperature, increasing pressure or other ways. Obviously, contents of the acceleration factor function is decided by the difference between the testing environment and the normal operating environment, and the 25 acceleration factor function could be a constant, a linear function or a nonlinear function. Further, as discussed above, the failure rate versus testing time relation can be divided into three periods in according to value of the testing time, the three periods are aan infant mortality

period, a normal life period and a wear out period.

As simulating block 23 shows, performs a simulating process that uses a ~~testing~~ function for curve fitting to simulate the experimental failure rate versus testing time relation. Whereby, the simulating process is adjusted to let an error, such as the least squares error method, between the experimental failure rate versus testing time relation and the simulated failure rate versus testing time function is minimized. ~~Further, the testing time function is a function of testing time.~~ Moreover, because usually only the infant mortality period and the normal life period must be considered, and also owing to the hint of FIG. 1, the ~~testing time test life~~ function for curve fitting usually is an exponent function, a~~an~~ polynomial equation of failure rate and testing time or $y=at^b$, wherein a and b are two variable parameters, y is the failure rate and t is the testing time. The parameters a and b can be obtained from the substitution of experimental data of failure rate and testing time for y and t. The simulated failure rate versus testing time function $y=at^b$ is then obtained, wherein parameters a and b are obtained from the experimental data of failure rate and testing time.

As transforming block 24 shows, performs a transforming process that uses the acceleration factor function to transform the simulated failure rate versus testing time function into a real failure rate versus operation time function. Whereby the knee point of the real failure rate versus operation time function corresponds to an operation time which is the best burn-in time. By referring Referring to FIG. 1, it is reasonable that while the difference between the simulated failure

rate versus testing time function and the real failure rate versus operation time relation is properly minimized by the simulating process, the knee point should corresponds to the end of the infant mortality period and also corresponds to beginning of the normal life period.

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As integrating block 25 shows, performs an integrating process that integrates the real failure rate versus operation time function through a calculating region to ~~consult obtain a yield ratio~~ normal chip number ~~equal to the area under the curve of the real failure rate~~ versus operation time function ~~an accumulated failure rate~~ real time function. Whereby, the calculating region is a region in which the real time is larger than the best burn-in time. Certainly, because integrated circuits usually never are used to the wear out period, it is reasonable that integrating process is stopped while said testing time in which is corresponds by said testing time is located in said wear out period, and then result of the integrating process is the accumulated failure rate during the normal life period.

~~Another embodiment of the invention also is a method for determining failure rate and selecting best burn in time. As FIG. 3 shows, the embodiment comprises following essential steps:~~

~~As preparing block 31 shows, provide numerous integrate circuits.~~

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~~As life time testing block 32 shows, performs a life time testing process to establish a failure rate testing time relation by measuring the life time of each said integrated circuit under a testing environment.~~

Moreover, an acceleration factor function also is established under the testing environment. Herein, the acceleration factor function is related to the relationship between a testing time of the testing environment and a real time of the normal operating environment.

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As transforming block 33 shows, performing a transforming process by using the acceleration factor function to transform the failure rate testing time function into a failure rate real time function.

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As simulating block 34 shows, performing a simulating process that uses a real time function to simulate the failure rate real time relation. Whereby, a knee point of the real time function corresponds to an operation time which is a best burn in time for testing these integrated circuits.

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As integrating block 35 shows, performing an integrating process by integrating the real time function through a calculating region to consult an accumulated failure rate real time function. Whereby the calculating region is a region in which real time is larger than the best burn in time.

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Indisputably, while the acceleration factor function is a constant, the result of performing the simulating process under the testing time is similar to the result of performing the simulating process under the real time, the only difference is the effect of constant. However, while the acceleration factor function is a linear function or a non-linear function, owing to the transformation between the real time and the testing time is not multiplied by a constant or divided by a

constant, the knee point of the testing time function usually is different from the knee point of the real time function. In other words, previous embodiments are equivalent while the acceleration factor function is a constant and are not equivalent while the acceleration factor function is not a constant. Moreover, while the acceleration factor function is not a constant, when to perform the simulating process should be decided by the practical effect of the claimed invention. Furthermore, the simulating process can be performed at any time while the acceleration factor function only is a constant; but the timing for performing the simulating process should be decided by both the accumulated failure rate real time function time and the best burn-in time while the acceleration factor function is not a single constant

Obviously, because the claimed invention never uses any mathematical formula also never uses any external parameter which is not consulted obtained from the testing records, and also because the claimed invention is a numerical approach method, it is reasonable that the claimed invention can decide the error range by "try and error" and also can decide the precision of the consulted obtained accumulated real failure rate versus real operation time function.

Besides, because calculation and application of the knee point is a key point of the claimed invention, and because precision of knee point is directly proportional to cost of the claimed invention. Calculation is further discussed in following paragraphs.

First, the failure rate versus testing time relation is combined by numerous testing records, the failure rate versus real time relation also

is combined by these testing records, and the differences are only the acceleration factor function.

Next, while more than one integrated circuits are failed before a specific testing time in which is corresponding to the knee point, it usually is necessary to perform an optimizing-optimization process that deletes part of testing records and performs corresponding processes. While only one integrated circuit is failed before a specific testing time in which is corresponding to the knee point, the specific testing time is a best testing time of these integrated circuits.

For example, while the failure rate versus testing time relation is as shown in FIG. 4A that the curve is formed by following testing records 6H-12H-18H ...and so on, it is obviously that 12H, the second testing record, is a good knee point and no other obvious knee point is existent, and then the required time function can be consulted from following testing records 6H-12H-23H ...and so on. However, while the failure rate versus test time relation is as shown in FIG. 4B that curve is formed by 6H-12H-18H-24H(knee point)-30H... and so on, or while the failure rate versus testing time relation is as shown in FIG. 4C that curve is formed by 6H-12H-18H(near knee point)-24H(near knee point)-30H...and so on, it is necessary to delete the first few testing records, for example deleting the 6H and 12H for FIG. 4C and deleting 6H for FIG. 4D, to let the knee point is the second used testing recorded. And the time function is calculated while the knee point is properly selected.

Without any question, while it is necessary to decrease the

total failure probability that the integrated circuit is used by an end-used during the normal life period, and while at least one testing record is existent after the knee point, it is useful to move the knee backward to prolong the best burn-in time and decrease the normal life period. Moreover, while advantages of both prolonged best burn-in time and decreased failure probability can not cancel the disadvantages of both increased production cost and quality controlling cost, the claimed invention also provides some trustable information to notice both the produce line and the customers that failure probability only can be decreased by improvement of fabrication.

Besides, while these is no enough testing records to ensure the precision of the knee point, the claimed invention can be further expanded to test same integrated circuits several times and find the best knee point by all testing records of all tests.

Although specific embodiments have been illustrated and described, it will be obvious to those skilled in the art that various modifications may be made without departing from what is intended to be limited solely by the appended claims.